AGENCY FOR INTERNATIONAL DEVELOPMENT
PPC/CDIE/DI REPORT PROCESSING FORM

ENTER INFORMATION ONLY IF NOT INCLUDED ON COVER OR TITLE PAGE OF DOCUMENT

1. Project/Subproject Number

497-0357

2. Contract/Grant Number

497-C-00-98-00045-00

3. Publication Date

October 2000

4. Document Title/Translated Title

Inflation Targeting in a Dynamic General Equilibrium Model: The Case of Indonesia

5. Author (s)

1. Paul D. McNelis
2. Charles P. Joseph
3.

6. Contributing Organization (s)

Nathan/Checchi Joint Venture/PEG Project

7. Pagination

25

8. Report Number

PEG 37

9. Sponsoring A.I.D. Office

ECG, USAID/Jakarta

10. Abstract (optional - 250 word limit)

This paper is a review of monetary policy issues for Indonesia and presents "forward-looking simulations" of alternative inflation-target rules for interest rates. The results show that there is a danger that over-emphasis on tight inflation targets may do more harm than good, by suppressing growth in domestic demand. The better policy stance should be to accommodate the fragile recovery process in a reasonable way, allowing the real exchange rate to appreciate, and the trade surplus to fall, through tolerance of higher inflation in the non-traded goods sector, for the medium term.

11. Subject Keywords (optional)

1. Indonesia
2. Inflation
3. General Equilibrium Model
4. Targeting inflation
5. Dynamic GEM
6. Monetary policy

12. Supplementary Notes

13. Submitting Official

C. Stuart Callison, Chief of Party

14. Telephone Number

011-62-21-520-1047

15. Today's Date

17 September 2001

…...………………………………….…………DO NOT write below this line……………………………….….………

16. DOCID

17. Document Disposition

DOCRD [ ] INV [ ] DUPLICATE [ ]

AID 590-7 (10/88)

Inflation Targeting in a Dynamic General Equilibrium Model:
The Case of Indonesia

Paul D. McNelis[1]
Department of Economics
Georgtetown University
Washington, D.C. 20057-1036
Email: McNelisP@georgetown.edu
Charles P. Joseph, Janu Dewandaru, Hidayeh Dhini Ari
Research Department
Bank Indonesia
CJoseph@bi.go.id

January 2001

Abstract

This paper is a review of monetary policy issues for Indonesia and presents "forward-looking simulations" of alternative inflation-target rules for interest rates. The results show that there is a danger that over-emphasis on tight inflation targets may do more harm than good, by suppressing growth in domestic demand. The better policy stance should be to accommodate the fragile recovery process in a reasonable way, allowing the real exchange rate to appreciate, and the trade surplus to fall, through tolerance of higher inflation in the non-traded goods sector, for the medium term.

1 Introduction

This paper is a review of inflation targeting and relevant monetary policy issues for Indonesia. Indonesia is in a fragile recovery mode, and there is a danger that over-emphasis on tight inflation targets may do more harm, than good, in terms of suppressing overall growth in demand. The policy stance of Bank Indonesia should be to accommodate the

---

recovery process in a reasonable way, by allowing an appreciation of the real exchange rate, and a fall in the trade surplus The correction of the "misaligned" real exchange rate towards a longer term real exchange rate consistent with a sustainable trade balance may mean temporary higher inflation in the non-traded sector of the economy.

The issue of the "appropriate" level of inflation for the "inflation targeting program" of monetary policy is thus of critical importance. The inflationary consequences of monetary policy, except in cases of hyperinflation, are long-run phenomena, and relate to the length and breadth of economic cycles, and not the least, to the length of the recovery cycle. Thus, making the measured "annual" inflation rate the "target" for current monetary policy misaligns the "target frequency" with the "instrument accountability" interval. Yes, monetary authorities should be held accountable for inflation, but for average inflation rates over a four to five year period, the length of the "recovery cycle" in Indonesia, during which the real exchange rate will adjust to its long-run level consistent with a sustainable trade balance.

The next section is a review of some recent developments on business cycles and monetary policy issues relevant for Indonesia. This literature focuses on the idiosyncratic nature of economic cycles in emerging markets, the design of feedback mechanisms for monetary policy, as well as the use and abuse of exchange rate targets. The third section is a description of a small model for capturing many of the relevant features of the current state of the economy. The fourth section is a simulation of different policy stances under similar sets of exogenous factors and shocks impinging on the economy, to see which type of "feedback rule" does best. The last section concludes.

2   Recent Developments and Relevant Policy Issues

This section takes up the following issues relevant to any discussion of monetary policy for Indonesia: (1) the nature of economic cycles in emerging market; (2) the perils of Taylor rules; (3) nominal and real exchange rate as policy targets; and (4) the use of the nominal exchange rate as a policy instrument rather than a policy target.

2.1   Economic Cycles in Emerging Markets

One major issue for policy making is the nature of the business cycle in emerging market economies. Traditional "real business cycle" general equilibrium models, starting with Kydland and Prescott (1982), have focused on productivity shocks as the driving force of real volatility. Their analysis was based on linearization around a steady state. The implicit assumption of this methodology is that fluctuations represent "small perturbations" around a long-term trend or "steady state".

Enrique Mendoza (1995) was one of the first to make use of non-linear dynamic general equilibrium models for investigating the nature of business cycles in emerging market economies. In contrast to many of earlier real business cycle models, which "linearized" the Euler equations around a steady state, Mendoza took another approach. He pointed out that such linearizations may be unreliable for the case of developing countries, due to the "large magnitude" of the terms-of-trade shocks and "their interaction with productivity shocks" [Mendoza (1995), p. 118]. Instead, Mendoza uses a value function iteration procedure, with discrete grids to approximate the "state space" of possible solutions. The drawback of this

approach, as he admits, is that it allows only a simple representation of the shocks and of course, is very computationally intensive.

In particular, Mendoza showed that a general equilibrium model, subject to terms of trade shocks, typically experienced by emerging-market countries, could replicate the following stylized facts:

1. net exports and terms of trade correlations are low and positive

2. cycles are larger in developing countries

3. variability measures, correlations with gdp, and own autocorrelations are similar to those of developed countries

4. real exchange rate fluctuations are large and procyclical

Since Mendoza's work, and the onset of the Asian crisis, interest is not only on the effect of terms trade but also on the effects of changes in international risk premia, world interest rates, and world overall demand, on macroeconomic adjustment. Specifically, how do changes in these variables affect key characteristics of the business cycle, the volatility of the real exchange rate, and the speed of recovery after an economic downturn?

Of course, besides the effects of terms of trade, other types of "shocks" such as changes in risk premia, international interest rates, and world demand, are also of interest. Similarly, the choice of policy rules is also of considerable importance for adjustment. These topics follow.

2.2 Inflation Targeting and the Perils of Taylor Rules

There has been a recent explosion of research using these models to evaluate "Taylor rules", in which the monetary policy instrument, usually the short-term interest rate, adjusts either to lagged or expected inflation less a target value of inflation, as well as to a measure of the "output gap", defined as the difference between the logarithm of actual gross domestic product and the trend level of gdp. In addition, the current short-term interest rate may also depend on its own lag. This reflects the effect of monetary authorities to "smooth" their adjustment of interest rates.

Taylor (1993) has pointed out that such a "rule" is really a policy *guideline*, rather than a hard and fast mechanical program, for indicating the stance of monetary policy, in response to developments in inflation and output. Such a rule does not mean the absence of "discretion". From time to time, the long run policy objectives can change, so that the rule itself will evolve. The central bank is committed to a rule, but with discretion.

Much of the controversy about Taylor rules centers around the weights that should be assigned to measures of the "output gap" relative to the inflation measures. But more recently, there have been warnings that the use of the Taylor rule with too low a target may plunge the economy into a continued deflation and a "liquidity trap".

Unfortunately, there is no consensus in the literature about how such a Taylor rule should be specified. Most of the models used to analyze different monetary policy rules rely on "one good" closed-economy dynamic general equilibrium models with sticky prices. Without some degree of price stickiness in this type of framework, there would be no point in discussing monetary policy, since monetary policy would only affect the price level with no effect on the real sector.

3

One major issue is the choice of the operating instrument: should the monetary authority best target inflation through a k-percent rule for base money or use the short-term interest rate? Végh (1998) has shown that there are some basic equivalencies among alternative policy instruments and policy rules. By "equivalence", he means rules that would yield the same dynamic patterns for money, output and interest rates in response to a policy target, such as a reduction in long term inflation. Using this "equivalence measure", he established that a simple k-percent rule for base money, with no feedback from output gap, a nominal interest rate rule depending only on an inflation target, and a real interest rate rule, based on both inflation and the output gap, yield the same dynamic paths.

Christiano and Guest (2000), on the one hand, argue for a rule in which only the inflation variable is used, so that the monetary instrument does not change in response to deviations of output relative to trend. However, their results come from a one-good general equilibrium model which has frictions in the credit markets, rather than price stickiness.

Rotemberg and Woodford (1998) similarly argue for an interest-rate rule, linked only to inflation, with a sticky price, one good model, but they argue that a high average rate of inflation is required for monetary policy to do its job over the medium and long term. Their argument is straightforward: if inflation is very low, nominal interest rates also are low. Since nominal interest rates are bounded from below by zero, this instrument has little room to manoeuvre at long term very low inflation rates.

Erceg, Henderson, and Levin (1999), on the other hand, favor an interest-rate rule based on the "output gap" as well as inflation, but they define a new measure of the "output gap": the difference in the level of output under sticky prices from the level of output under flexible prices.

The issue of longer-term policy "ineffectiveness" under low inflation, due to the zero lower bound on interest rates, is challenged by McCallum (2000). McCallum argues that the central bank has a second tool for monetary policy: the exchange rate. If the economy is stuck at a low interest rate, the monetary authority can use currency intervention to get the economy out of this "worst case scenario". Christiano (2000) takes issue with McCallum, by noting that this position rests on two assumptions: first, the depreciation through currency intervention is effective, and secondly, he bypasses the fact that public "confidence" in financial markets rests on the perceived commitment that the central bank stands ready to cut interest rates in the event of major shocks.

Benhabib, Schmitt-Grohé and Uribe (1999) and Schmitt-Grohé and Uribe (2000) have analyzed both the "perils" and "traps" associated with Taylor rules in a "global" general equilibrium setting. They point out that once the zero bound on interest rates are taken into account, "active interest rate feedback rules can easily lead to unexpected consequences". They warn that there "typically exists" an infinite number of equilibrium trajectories originating arbitrarily close to a steady state which "converge to a liquidity trap" [Benhabib, Schmitt-Grohé and Uribe (1999): p.1]. They also point out that even if the government can ignore the zero bound by setting the nominal interest rate at a negative value, "self-fulfilling liquidity traps can still emerge" [Schmitt-Grohé and Uribe (200): p.1].

There has been little research on the implementation of a Taylor rule in dynamic model specified for emerging market economies. Mishkin (2000), for example, hedges his bet on inflation targeting in this context. He acknowledges that inflation targeting may not be "appropriate" for many emerging market countries, but states that it can be "highly useful" in many of them.

2.3 Nominal and Real Exchange Rates as Policy Targets

There is also the very important question of how much to raise the interest rate against unexpected currency depreciations. Stanley Fischer (1998) has argued that a "key lesson" of recent crises is that the "first order of business" is to "restore confidence in the currency" by a "timely and forceful tightening of interest rates" .

However Jeffrey Sachs (1997) and Joseph Stiglitz (2000) have assailed this policy prescription. Sachs said such a program transforms a currency crisis into a "rip-roaring economic downturn". Stiglitz called this policy "totally misguided" since it provides "little benefits" while plunging the economies into a deep recession by "devastating highly indebted firms and causing widespread bankruptcies".

Lehiri and Végh (2000) make use of a one-good dynamic general equilibrium model, with a banking sector and a "transactions costs" model of money demand. They find that high interest rates often lead to a credit crunch and output contraction. Particularly, in the presence of a fiscal constraint, movements of the exchange rate may be a non-monotonic function of increases in the interest rate, appreciating for small increases but depreciating beyond a certain point.

The key question for monetary policy, of course, is to determine this "threshold" or point, beyond which interest rate increases fail to improve the exchange rate. The very real danger in this situation is that the interest rates will generate all of negative consequences while providing none of the benefits.

The response of McCallum (1999a) to reservations about the zero lower bound on interest rates implies that exchange rate intervention is always an option. If so, should a stable real exchange be a "target" for an exhange-rate intervention rule? Put another way, what should be the reaction of monetary policy to real exchange rate developments. Should policy makers react to perceived misalignments through a purchasing power parity (PPP) "rule" or guideline for the exchange rate, akin to a Taylor rule or "guideline" for inflation?

Dornbush (1982) used a "Mundell-Fleming" type model and found in this set-up that PPP rules always increase the volatility of prices after supply shocks. Later, Calvo, Reinhart and Végh (1995) used a general equilibrium model with one good and with a cash-in-advance constraint. They found that the government can obtain a depreciated real exchange rate through a temporary increase in the rate of depreciation but the gain in competitiveness is transitory. Finally, Uribe (2000), making use of a two-good general equilibrium model, argues that such a PPP rule can have "unintended consequences", in terms of "opening the door" to endogenous fluctuations" in real output. This result is robust to the assumption of sticky or flexible prices.

2.4 Use of Exchange Rate in Stabilization

The broader issue is the role of the exchange rate as a stabilization instrument, either fixing the exchange rate to stabilize inflationary expectations, or to intervene in order to maintain a "competitive" real exchange rate. Exchange-rate based stabilization was a key ingredient in both the "new orthodox" programs in Argentina, Chile and Uruguay in the late 1970's, in the as well as in the "heterodox" programs in Argentina and Brazil in the mid-1980's.[2] The traditional "orthodox" approach is the use of a money-based stabilization program.

---

[2] See Mendoza and Uribe (1995) for an analysis of exchange-rate based stabilization programs

Calvo and Vegh (1998) have analyzed the effects of both monetary-based and exchange-rate-based stabilization programs with general equilibrium models.

They found the following "stylized facts" characterizing monetary-based stabilization:

1. slow convergence of the rate of growth of the money supply and inflation

2. cycles are longer in less developed countries

3. no clear cut response of the trade balance and current account

4. real appreciation of the domestic currency

5. initial sharp contraction in economic activity

6. initial increase in domestic real interest rates

For exchanged-based stabilization, the following "facts" were noted:

1. slow convergence of inflation to the devaluation rate

2. initial increase in real activity

3. real appreciation of the domestic currency

4. deterioration of the trade and current account balance

5. ambiguous impact effect of domestic real interest rates

What is at issue in more recent work on the use of the exchange rate as a "policy instrument" is the social cost of "devaluation risk", in terms of prolonging the length of economic downturns during a business cycle. Mendoza and Uribe (2000) analyzed devaluation risk with a two-sector dynamic model, in which there are incomplete insurance markets Calibrated to Mexican data, their model shows that the distortions due to such risk can be "large and socially costly" while rationalizing several stylized facts.

Closely related to the social cost of exchange-rate instability is the "pass-through" effect, is the relation of the rate of exchange rate depreciation and the rate of growth of domestic prices a stable one? Obviously, the use of the exchange rate as a policy instrument for domestic inflation would not make sense if the pass-through effect did not matter very much.

While the large drop in the Asian currencies in 1998 led to bursts of high inflation in 1998, the link between exchange-rate and domestic price movements has become much less clear after that.

One way to examine the issue of the pass-through effect is to make use of a two-sector model, in which there are both tradeable and non-tradeable goods. The larger the relative size of the non-traded goods sector, of course, the less important is the pass-through effect. The non-traded sector will become more important as the real exchange rate appreciates, and resources are diverted into the non-traded sector from the traded-good sector.

Another way to examine the pass-through effect is to look at pricing-setting behavior. Betts and Devereux (1998), for example, made use of a general equilibrium model to investigate the implications of "pricing to market" (PTM) behavior, in which markets become segmented, and prices are set in local currency of country of sale. Their finding is that the higher degree of PTM, the higher is the co-movement in production across countries,

but the lower is the co-movement of consumption across countries.

3 A Prototype "Flight Simulator" for Policy Analysis

The computational stochastic dynamic general equilibrium framework is a ready tool for analyzing a host of policy issues, ranging from the expected adjustment from changes in international risk premia, to the consequences of monetary growth targets, to the effect of "pass-through" exchange rate issues.

Each of the above policy issues, of course, may be investigated in isolation, under the *ceteris paribus* assumption, or in a computational general equilibrium setting, pure theoretical studies, taking apart illustrative cases, with the aid of partial equilibrium models or very simple,stripped down simple general equilibrium models. However, Judd (1998) reminds us of Eienstein's recommendation–that a model should be as simple as possible "but not simpler". Judd acknowledges that simple focused studies can give us much insight, but they can only serve as a "step" in any substantive policy analysis, not the "final statement".

To evaluate the response of the economy to different external or internal shocks, under different policy rules, means setting up a computational dynamic general equilibrium model and evaluating the robustness of its performance, under a variety of scenarios or structural changes which are likely to take place, over the coming years. Much as test pilots can make use of flight simulators in order to prepare for turbulent situations in the air, policy makers can make use of dynamic general equilibrium models in order to assess how specific inflation targeting rules, for example, may be implemented under alternative conditions of duress, without unduly harming the process of recovery and adjustment.

Of course, as should be clear from the above survey is issues, different general equilibrium models can generate different effects, so it is essential to have a good strategy for developing a good dynamic and stochastic general equilibrium model. As McCallum (1999c) points out, it is desirable for a model to be consistent with both economic theory and empirical evidence, but this "dual requirement" is only a starting point for consideration of numerous issues. McCallum also points out, "depicting individuals as solving dynamic optimization problems", as is done in general equilibrium settings, is "useful in tending to reduce inconsistencies and forcing the modeler to think about the economy in a disciplined way" [McCallum (1999c) p. 15].

To capture some of the key characteristics of emerging market economies,this study works from the beginning with a two-sector open economy model, one sector for traded goods and the other for non-traded goods.

The model has three assets: domestic money, domestic bonds, and foreign liabilities. The traded sector "clears" through quantity-adjustment, in the sense that excess supply of traded goods are net exports. The non-traded sector has sticky price-adjustment, so that excess demand or supply lead to slow changes in the price of non-traded goods.

This model may be divided into three sets of equations: static and definitional equations, backward-looking dynamic equations, and forward-looking dynamic equations. To give life to the model, we assume that the foreign interest rate,i*, the risk premium, θ,as well as production and government spending in the traded and non-traded sectors are also influenced by stochastic shocks $\{\varsigma\}$.

3.1 Static,Definitional, and Technological Equations

Money Demand	$m = \chi \frac{c^{\eta}}{i}$ or i=$(m,c), i_m < 0, i_c > 0$
Real Interest Rate	$r = i - \pi$
Non-traded consumption	$c_n = \delta z^{1-\delta} c$
Traded consumption	$c_T = (1-\delta) z^{-\delta} c$
Real exchange rate	$z = E/P_N$
Non-traded production	$y_n^s = y_n^s(z) + \varsigma_{y_n}, y_n^{s'} < 0$
Traded production	$y_T^s = \varepsilon^T y_T^s(z), y_T^{s'} > 0$
Risk premium	$\theta = \theta(l^*) + \varsigma_\theta, \theta' > 0$
Money	$m = z^\delta R^* + d$
International interest rate	$i^* = i^* + \varsigma_{i*}$
Government Spending	$g_h = \overline{g_h} + \varsigma_{g_h}, h = N, T$

3.2 Backward-Looking Dynamic Equations

Current account
$$l_t^* - l_{t-1}^* = i^* l_{t-1}^* + \theta(l_{t-1}^*) l_{t-1}^* + (1-\delta) z^{-\delta} c + g_T - y_T^s$$
Non-traded inflation
$$\ln(P_{n,t}) - \ln(P_{n,t-1}) = \gamma[\delta z^{1-\delta} c + g_n - y_n^s]$$
Real exchange rate
$$\ln(z_t) - \ln(z_{t-1}) = [\ln(E_t) - \ln(E_{t-1})] - [\ln(P_{n,t}) - \ln(P_{n,t-1})]$$
Government budget
$$b_t - b_{t-1} = z^\delta(g_T + g_n/z) + rb - z^\delta(i^* + \epsilon) R^* - \pi m - \tau$$
Inflation
$$\pi = \ln(P_t) - \ln(P_{t-1}) = [\ln(E_t) - \ln(E_{t-1})] - \delta[\ln(z_t) - \ln(z_{t-1})]$$
Domestic credit:
$$d_t - d_{t-1} = (\mu - \pi) d_{t-1}$$

3.3 Forward-Looking Dynamic Equations

Aggregate consumption	$C_t^{-\eta} = \beta \lambda_{t+1} R_t$
Exchange rate depreciation	$\ln(E_{t+1}) - \ln(E_t) = i - [i^* + \theta - l^* \theta_{l*}]$

3.4 The Monetary Transmission Mechanism

How does monetary policy affect inflation in this model? The channel is through the nominal and real interest rate. A change in domestic credit initially increases the real stock of money, and via equation demand, lowers nominal interest rates.

The lower nominal interest rates lead to lower real rates, which in turn increase aggregate consumption demand, demand for non-traded goods, and an increase in the price of non-traded goods.

The other channel is through the interest parity relation. Lower nominal interest rates lead to an instantaneous depreciation of the exchange rate, and a higher price of traded goods.

Depending on the share of traded and non-traded goods in the overall price index, the "pass through" effect of exchange rate depreciation may be less than one. This transmission mechanism is illustrated in Figure 2.1.

Monetary Transmission in General Equilibrium Model

Increase in Nominal M	→	Increase in Real M

Decrease in Nominal Interest Rate	→	Decrease in Real Interest Rate

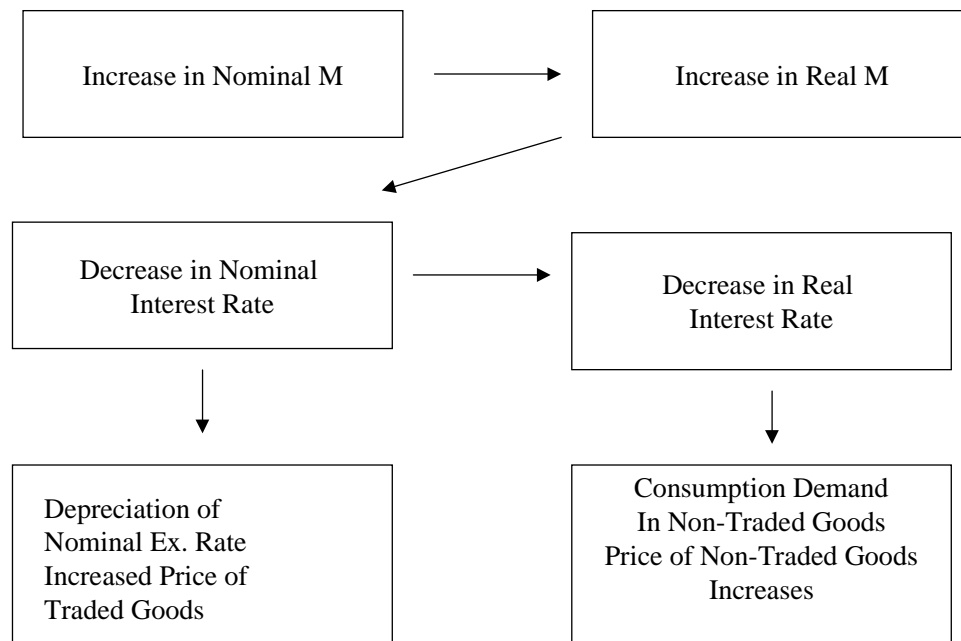| Depreciation of Nominal Ex. Rate Increased Price of Traded Goods		Consumption Demand In Non-Traded Goods Price of Non-Traded Goods Increases

Figure 1

3.5   Calibration of Parameters and Initial Conditions

In the spirit of Judd (1998), who reminds us that the basic objective of a numerical approach is to compute approximate solutions with "minimal error in minimal computer time, using minimal computer storage and minimal programmer time", the initial value of GDP is normalized at unity, rather than at a value in constant Rupiah. Similarly, the nominal exchange rate, the price of traded and non-traded goods, and the overall price index are

9

all nomalized at initial values of unity [see Judd (1998): p. 33]. Total consumption is approximately 80 percent of output, so the initial value of c is set at .8.

The relative risk aversion coefficient η is set at 5. This is the value used by Mendoza and Uribe (2000) in their recent study of the business cycle implications of exchange-rate management in developing countries, and represents the median of existing estimates for developing countries, reported by Reinhart and Vegh (1995). The annual rate of time preference ρ is assumed to be equal to the real risk-free international rate of interest, 0.04. For quarterly data, the discount factor $\beta = 1/(1 + \rho) = 1/1.01$. The coefficient of real money in the utility function, χ, is calibrated so that the first-order condition holds for the initial values of m and c, given the specification of η. Thus, $m = \chi \frac{c^\eta}{i} \Rightarrow \chi = \frac{mi}{c^\eta}$.

The share of non-tradeables in expenditure and production, δ, is set at .4, slightly above the value of .34 used by Mendoza (1992). Under the assumption of sticky prices of non-traded goods, γ, the coefficient of price adjustment in the non-traded sector, with respect to excess demand is set at .8. There is also the possibility of fully flexible prices in the non-traded good sector. In this case the real exchange rate adjusts to equilibrate consumption with overall supply in this sector.

In this case, we take money as broad money. Since real broad money is approximately 60 percent of GDP, we sent m = .6. We assume initially, under the flexible rate system, that R*, the stock of international reserves, is zero, and that all money is domestic credit, but we use the broad money/gdp ratio for calibrating the utility function, and the money/interest-rate relation. Later, when the banking system is introduced, there will be a distinction between domestic credit and the broader money aggregate which appears in the utility function.

With a real money/consumption ratio of .05, and an initial interest rate of .12, $\chi = .0720$.

For simplicity, the initial values for the stocks of domestic debt b and international debt l* are set at 0. Taxes τ adjust endogenously to maintain a balanced budget. In the initial base simulation, the risk premia θ will be independent of the stock of international debt l*. Later sections will develop the specification of l* as a function of debt.

3.6 Specifying the Processes for Output, Terms of Trade, and Money Shocks

The quarterly logarithmic first differences for real output, the non-oil terms of trade, and the broad money stock appear in Figure 2-4 through 2.6.
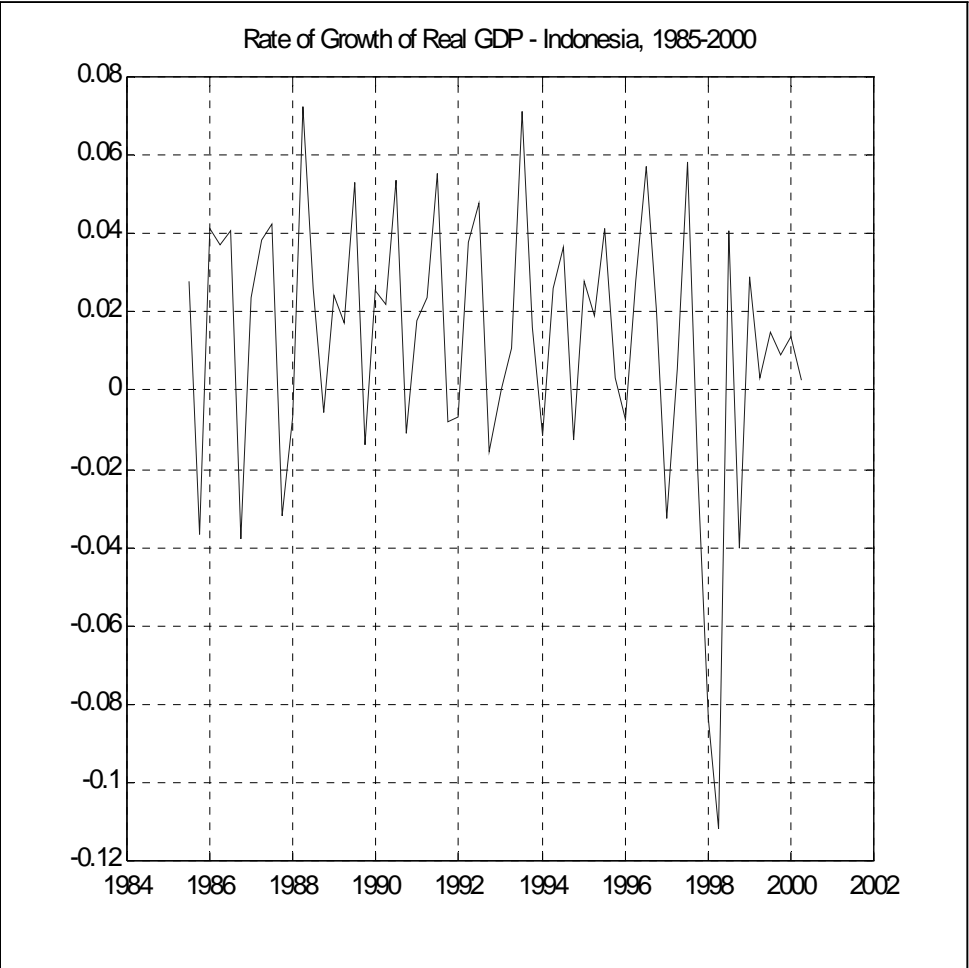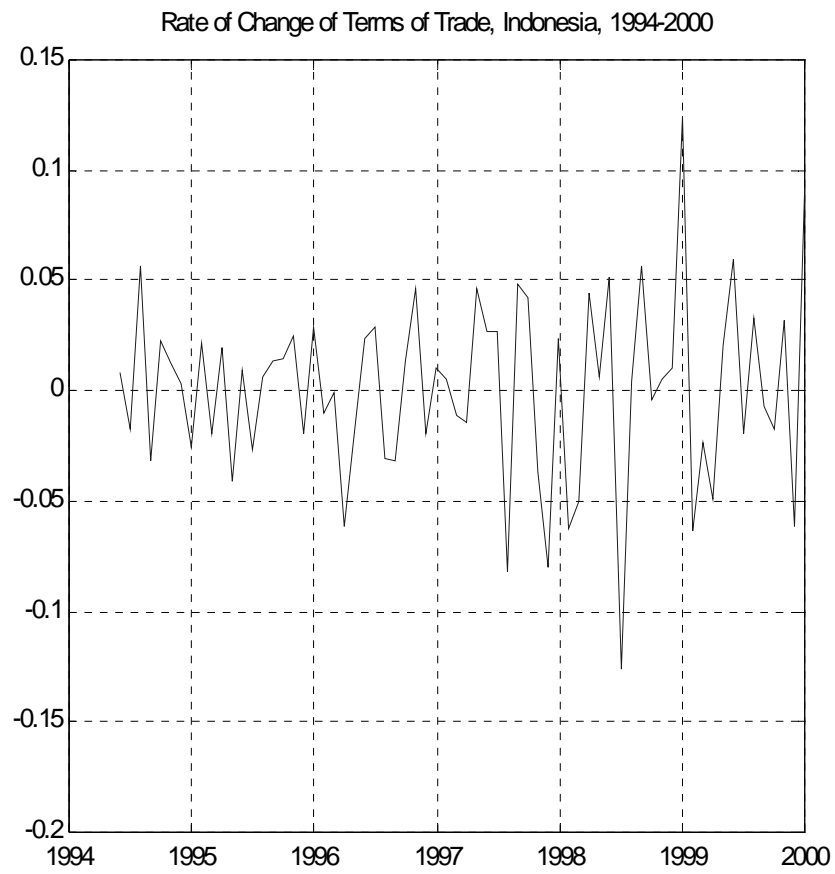
Figure 2

Rate of Change of Terms of Trade, Indonesia, 1994-2000

3

Figure 3
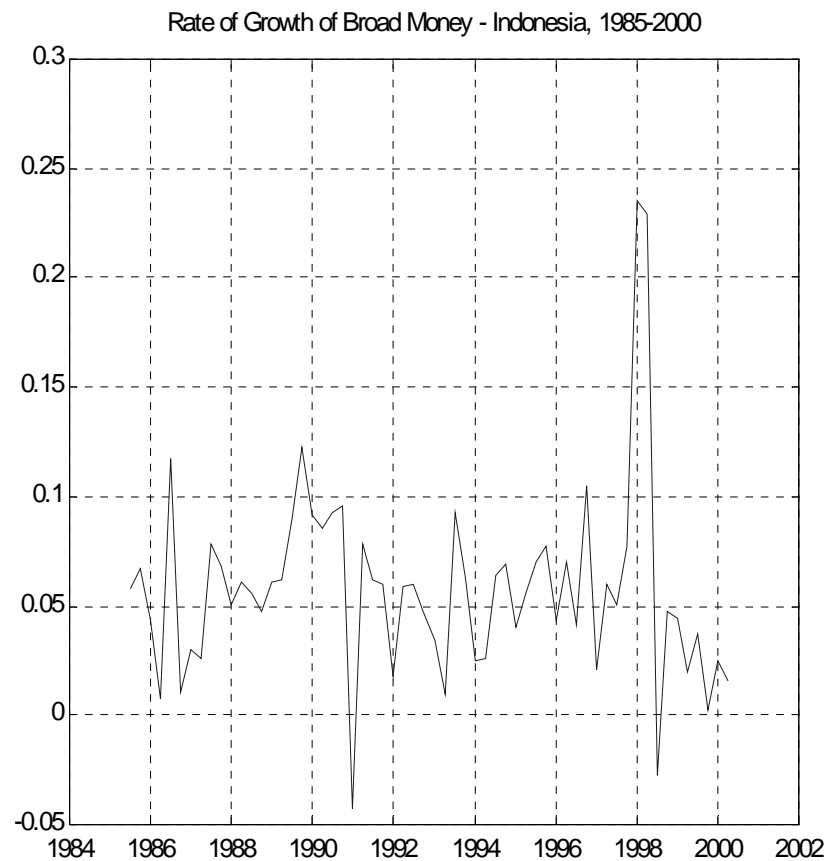
Rate of Growth of Broad Money - Indonesia, 1985-2000

Figure 4

One cannot help but notice the large negative shock to real gdp growth and the large positive shock to monetary growth at the time of the monetary crisis after 1998.

The annualized means and standard deviations appear in Table I.

Descriptive Stats:	GDP-Growth	Terms of Trade-Growth	M2-Growth
Mean	.051	0.0113	.232
Annualized Standard Deviation	.068	.146	.091

Table I

The exogenous process for y_N, y_T, and m will be simulated as a quarterly unit-root processes. The logarithm of each variable depends on its own lag, plus a random normal shock with the quarterly mean and quarterly standard deviation taken from Table 3.5. In the

simulation M2 is endogenous so a feedback rule for the interest rate will be used, based on an empirically estimated "quasi-Tayor" rule, discussed below.

3.7 Specifying Markov Processes International Interest Rate, Risk Premium, and Government Expenditures

The shocks of international interest rate i*, to θ^* ,the risk premium, may be modelled as a finite state Markov process. For the foreign interest and the risk premium, one is usually interested in a finite number of states, such as a good outcome, a neutral outcome, or a bad outcome. In policy terms, for example, the interest is whether the risk premium will be better than normal, normal, or worse than normal. Secondly, in terms of specification, we assign at time 0, the initial period, the starting unconditional probabilities as well as the transition probabilities of moving from one state to another. There is thus no need to estimate a complex autoregressive process for these variables, for which there are only a finite number of possible outcomes.

The Markov process is described as follows. Since any stochastic process is a sequence of random vectors, a process with a Markov property is given for all t:

$$\Pr(x_{t+1}|x_t, x_{t-1}, ..., x_{t-k}) = \Pr(x_{t+1}|x_t)$$

Following Ljungqvist and Sargent (1999), a Markov chain is characterized by a triplet of objects:

(i) an n-dimensional vector that records the possible values of the state of the system of shocks;

(ii) an (n x n) transitional matrix P, which records the probabilities of moving from one state to another in one period; and

(iii) an (n x 1) vector p_0 giving the probabilities of being in each state i at time 0.

The matrix P has the interpretation:

$$P_{ij} = \Pr(x_{t+1} = \overline{x_j}|x_t = \overline{x_i})$$

Both P and p satisfy the following properties:

$$\sum_{j=1}^{n} P_{ij} = 1$$
$$\sum_{i=1}^{n} p_{0i} = 1$$

The matrix P is called a stochastic matrix. The stochastic matrix defines the probabilities of moving from any values of the state to any other in one period. The probability of moving from any value of the state to any other in two periods is determined by P^2. We thus have:

$$P_{ij}^k = \Pr(x_{t+k} = \overline{x_j}|x_t = \overline{x_i})$$

The unconditional probability distributions are determined from:

$$
\begin{aligned}
p_1^{'} &= \Pr(x_1) = p_1^{'}P \\
p_2^{'} &= \Pr(x_2) = p_0^{'}P^2 \\
&\quad . \\
&\quad . \\
&\quad . \\
p_k^{'} &= \Pr(x_k) = p_0^{'}P^k
\end{aligned}
$$

where $\Pr(x_t)$ is the (1xn) vector whose i^{th} element is $\Pr(\mathrm{x}_t = \overline{x_i})$.

The advantage of the use of the Markov process is that it allows one to be explicit about one's subjective assessment of probabilities or likelihoods of upturns or downturns in key policy variables, including political uncertainty. One puts one's theoretical priors forward, about expectations of increases or decreases in international interest rates, risk premia, or the stance of the fiscal authority, based on assessments of underlying conditions.

For purposes of simplification, the stochastic processes for Z*=$\{i*, \theta^*\}$ are three-state Markov processes. The initial level of the nominal interest rate is .12.

For the foreign interest rate i*, there are three states,.a "bad" state of i* =.06, a "normal state of i*= .04, and good state of i* = .03. For the risk premium, θ^*, states,a "bad state" of $\theta^* = .10$, a "normal state" with $\theta^* = .08$, and a "good state" of $\theta^* = .06$. For each of these stochastic variables there is mild inertia: if one is in the high or low state, the probability of remaining in that state in the succeeding period is .6 and the probability of moving to each of the other states, .2.

For government expenditures on traded goods, there are three states, $g_t = \{.11\ .12\ .13\}$, and for government expenditures on non-traded goods, $g_n = \{.072\ .08\ 088\}$. These values represent small changes around the initial equilibrium level for government expenditures representing approximately 20 percent of total gdp.

4 Simulating Taylor Rules

4.1 Baseline Simulation

To simulate the model, a modified Taylor rule was used for the exogenous interest rate policy:

$$
i_t = b_0 + b_1 i_{t-1} + b_2[\ln(p_t) - \ln(p_{t-4}) - \Pi^*] + b_3[\ln(c_t) - \ln(c_{t-4}) - \Lambda^*] + \theta_t + \eta_{i,t}
\tag{1}
$$

$\eta_{i,t} \sim N(0, \sigma_i^2)$

where Π^* represents the target for the "annualized" or year-on-year rate of price change, and Λ^* the target for the corresponding year-on-year rate of consumption growth. Since output gap is difficult, if not impossible, to measure, the central bank could use a long-run

normal expected rate of growth of consumption as the "trend". If actual consumption growth is above this level, the output gap is positive, indicating an "overheated" economy, and interest rates should be raised. Thus the coefficient of this variable should be positive.

The parameter b_1 represents a "smoothing factor" for interest rate adjustment, whereas the parameters b_2 and b_3 are the weights on the deviations of inflation and consumption growth from their long-run targets. The risk premium, θ, is assumed to be taken into account when policy makers set the short-term interest rate.

The stochastic term $\eta_{i,t}$ represents the "shaky hand" style of control of the monetary authority over the short-term interest rate.

The parameters are set at $b_0 = 0.04, b_1 = 0, b_2 = 1.25, b_3 = .1$ and the targets $\Pi^* = .06, \Lambda^* = .04$, representing and annual inflation target of 6 percent and an annual consumption growth target of 4 percent. The "shaky hand" effect is set at zero, while θ_t follows the Markov process specified above.

Figure 5 pictures the adjustment of aggregate consumption, the price level, and the nominal and real exchange rates:
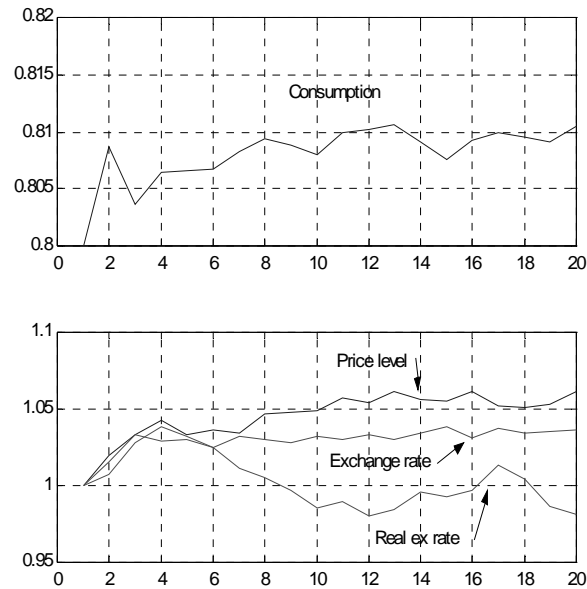

Figure 5

One notes in this simulation that there is a positive correlation between the medium-run real exchange rate appreciation (representing a decrease in the level of the real exchange

16

rate) and the medium-run increase in aggregate consumption. This correlation replicates a
"stylized fact" noted by Mendoza and Uribe (2000) for Mexico and other emerging market
economies during the 1980's and 1990's.

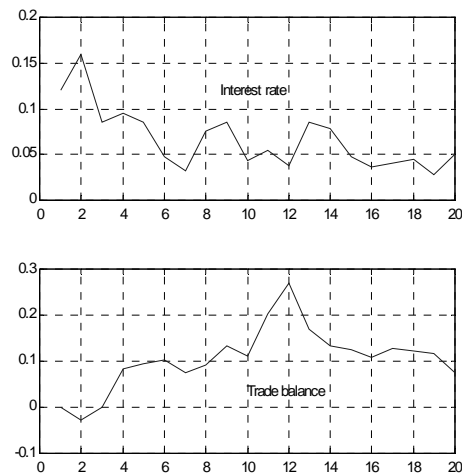Figure 6 pictures the adjustment of the nominal interest rate and the balance of trade.

Figure 6

One sees in this adjustment negative correlation of the interest rate with the trade balance
(and concomitant capital outflow).

The annualized inflation rate appears in Figure 7.

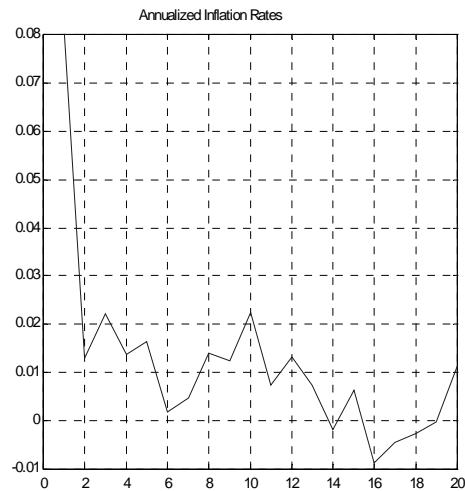Annualized Inflation Rates

Figure 7

4.2   Validation

One way to evaluate the "performance" of the simulated model is to compare the correlations or co-movements of the model-generated data with the correlations of the actual data, for the past ten years, through measures of relative volatilities of the artificial and actual data, and through simply "eyeballing" features of the "real world" and simulated data.

Actual Data: 1989-2000

	real money	consumption	price	exrate	real ex rate	interest
real money	1.0000	0.8885	0.8099	0.6897	0.3704	0.4132
consumption		1.0000	0.5487	0.3322	-0.0334	0.1014
price			1.0000	0.8620	0.5498	0.6577
exrate				1.0000	0.8735	0.8207
real ex rate					1.0000	0.7694
interest						1.0000

Artificial Data

	real money	consumption	price	exrate	real ex rate	interest
real money	1.0000	0.6210	0.4855	0.4718	-0.3063	-0.4836
consumption		1.0000	0.8944	0.8506	-0.4849	-0.5939
price			1.0000	0.9026	-0.6349	-0.6261
exrate				1.0000	-0.3560	-0.7452
real ex rate					1.0000	0.2359
interest						1.0000

Table II: Unfiltered Data

18

The correlations coefficients of the model simulations closely match those of the actual data for real money, consumption, the price level and the exchange rate However, the model fails to replicate phenomena.

Table III pictures the correlations for actual and artificial data, when the data are first-differenced.

Actual Data: 1989-2000

	real money	consumption	price	exrate	real ex rate	interest
real money	1.0000	0.0740	-0.4158	0.6452	0.7123	-0.1216
consumption		1.0000	-0.2976	-0.0660	-0.0082	-0.1093
price			1.0000	0.1756	0.0100	0.2501
exrate				1.0000	0.9840	0.0728
real ex rate					1.0000	0.0489
interest						1.0000

Artificial Data

	real money	consumption	price	exrate	real ex rate	interest
real money	1.0000	0.4452	0.2530	-0.1466	-0.1312	0.3864
consumption		1.0000	0.4446	-0.0103	-0.1159	0.4229
price			1.0000	0.0712	0.0030	0.4191
exrate				1.0000	0.2810	-0.3593
real ex rate					1.0000	-0.0875
interest						1.0000

Table III

The first-differenced data show the expected negative correlations between real exchange rates and consumption for both data sets. Both data sets also show low correlations between first differences in the price level and the exchange rate, indicating a low pass-through effect.

The relation between the rate of depreciation and the inflation rate, in both the actual and artificial data, in standardize units, appears in Figure 8.
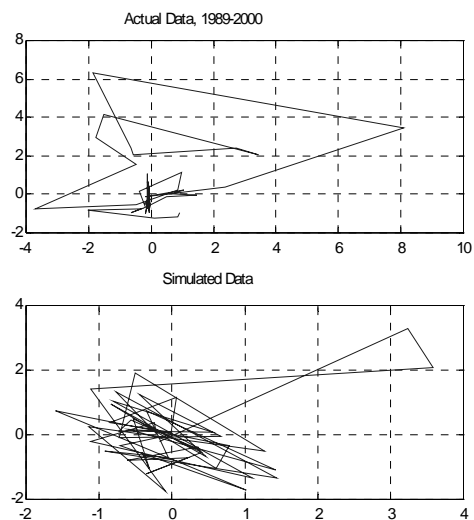
19

Figure 8

.

The model replicates some key features of the actual data, specifically the changing relations between the rate of exchange rate depreciation and the inflation rate, sometimes positive, sometimes negative, sometimes flat. Figure 8 shows that the actual data exhibits much more volatility than the artificial data but the overall pass through effect is unstable in both data sets.

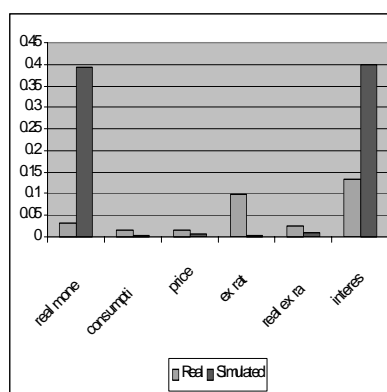Figure 9 pictures the relative volatilities of the first-differenced data for both data sets.

Figure 9

In terms of relative ranking of the variables,the model is consistent with the actual data,

in that consumption, the overall price level, and the real exchange rate show the lowest volatility. The model, consistent with the actual data, shows high interest rate volatility However the model predicts much higher real money stock volatility and much lower nominal exchange-rate volatility, than one observes in the data.

4.3   Simulation of Alternative Policy Rules

Since it is difficult to obtain accurate proxies for the output gap, an alternative Taylor rule would be to use excess demand in the traded goods sector, or the trade deficit, as an index of real sector "overheating":

$$i_t = b_0 + b_1 i_{t-1} + b_2[\ln(p_t) - \ln(p_{t-4}) - \Pi^*] + b_3[\frac{c_{T,t} + g_{T,t} - y_{T,t}}{y_{T,t}}] + \theta_t + \eta_{i,t} \quad (2)$$

$\eta_{i,t} \sim N(0, \sigma_i^2)$

This alternative was simulated for the same parameter values for the Taylor rule in the base simulation, as well as for the same stochastic shocks. Figure 10 pictures the dynamic paths of inflation and quarterly consumption growth for the modified Taylor rule as well as for the base rule.
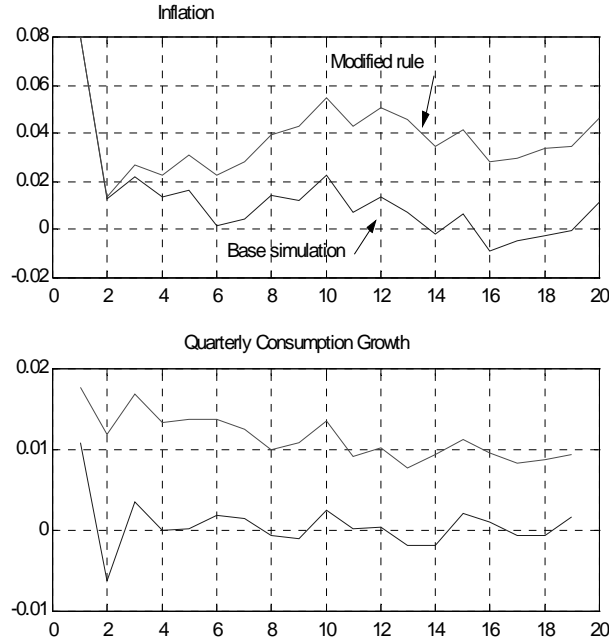

Figure 10

The higher consumption growth is due to real exchange rate appreciation, and of course, a lower trade balance. The paths of these two variables under the base simulation and the modified rule appear in Figure 11.
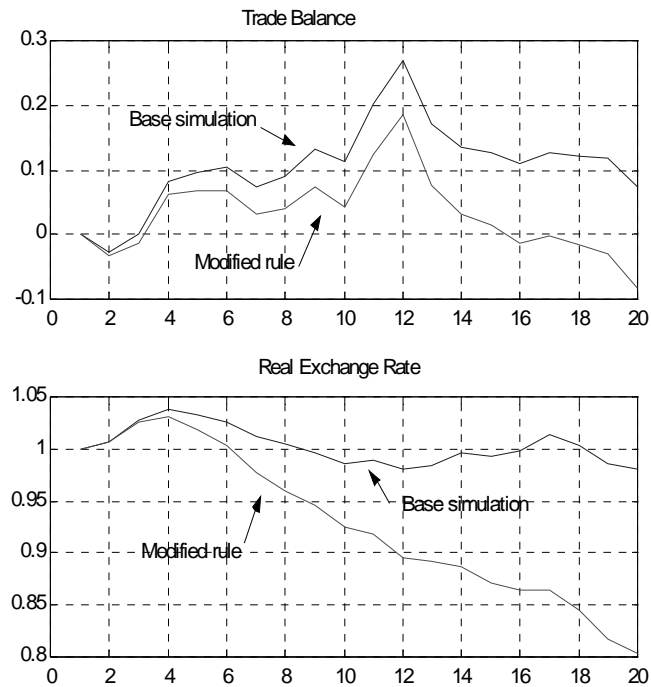

Figure 11

The results from Figures 10 and 11 suggest that a monetary policy "rule" or program should be "relaxed" about inflation, at lease in the fragile recovery process, to accommodate an increase in demand, and a reduction of the overall trade surplus, as the real exchange rate adjusts to a position consistent with a "sustainable" trade balance, consistent with normal capital inflows and longer-term growth.

5 Conclusion

This simulation study, of course, captures key challenges facing Indonesian monetary policy. There are sharp trade-offs between needed growth in demand and the prospect of "very low" versus a "moderate" inflation. The "moderate" inflation may simply reflect a correction of the "misaligned" real exchange rate toward a longer-term real exchange rate consistent with a sustainable and normal balance in the trade account.

This study has left out the question of the role of fiscal policy, public finance and debt restructuring. The question of the role of fiscal adjustment will be crucial for the "success"

of maintaining and "locking in" recovery. Obviously, there are many "shocks" affecting, at any one time, many different sectors of the economy. If monetary policy is to do its job, and have sufficient "manoeuvring room" to adjust short-term interest rates, without destroying fiscal sustainability, then the public finances will have to be put in order and public debt restructured. Fiscal policy itself will have to become an instrument for the recovery process. Simply put, monetary policy cannot do the job, all by itself.

References

[1] Agenor, Pierre and Peter Montiel (2000), *Development Macroecnomics*, Second Edition. Princeton, N.J.: Princeton University Press.

[2] Benhabib, Jess, Stephanie Schmitt-Grohé and Martín Uribe (1999), "The Perils of Taylor Rules". Forthcoming, *Journal of Economic Theory*.

[3] Black, Richard and David Rose (1997), "Canadian Policy Analysis Model: CPAM". Working Paper 97-16, Bank of Canada.

[4] Black, Richard, Vincenzo Cassino, Aaron Drew, Eric Hansen, Benjamin Hunt, David Rose, and Alasdair Scott (1997), "The Forecasting and Policy System: The Core Model". Research Paper 43, Reserve Bank of New Zealand.

[5] Calvo, Guillermo A., Carmen M. Reinhart, and Carlos A. Végh (1995), "Targeting the Real Exchange Rate: Theory and Evidence", *Journal of Development Economics* 47: 97-134.

[6] _____ and Carlos A. Végh (1998), "Inflation Stabilization and BOP Crises in Developing Countries". Working Paper, Department of Economics, UCLA. Website: http://vegh.sscnet.ucla.edu

[7] Christiano, Lawrence J. (1999), "Comment on Ben McCallum, 'Theoretical Analysis Regarding a Zero Lower Bound on Nominal Interest Rates'".

[8] _____ and Christopher J. Guest (1999), "Taylor Rules in a Limited Participation Model". NBER Working Paper 7017. Web page: www.nber.org/papers/w7017.

[9] Craine, Roger, Lars A. Lochester, and Knut Syrtveit (1999), "Estimation of a Stochastic-Volatility Jump Diffusion Model". Unpublished Manuscript, Department of Economics, University of California, Berkeley.

[10] Den Haan. W. and A. Marcet (1990a), "Solving the Stochastic Growth Model by Parameterizing Expectations", *Journal of Business and Economic Statistics* 8, 31-34.

[11] _____ (1994), "Accuracy in Simulations", *Review of Economic Studies* 61, 3-17.

[12] Dornbusch, Rudiger (1982), "PPP Exchange Rate Rules and Macroeconomic Stability". *Journal of Political Economy 90:158-165.*

[13] Duffy, John and Paul D. McNelis (2000), "Approximating and Simulating the Stochastic Growth Model: Parameterized Expectations, Neural Networks and the Genetic Algorithm". *Journal of Economic Dynamics and Control,* forthcoming. Web site: www.georgetown.edu/mcnelis.

[14] Erceg, Christopher J., Dale W. Henderson, and Andrew J. Levin (1999), "Optimal

Monetary Policy with Staggered Wage and Price Contracts". Working Paper, Board of Governors of the Federal Reserve System.

[15] Fischer, Stanley (1998), "The IMF and the Asian Crisis". Mimeo, International Monetary Fund.

[16] Hansen, Lars Peter and Thomas J. Sargent (2000), "Wanting Robustness in Macroeconomics". Manuscript, Department of Economics, Stanford University. Web site: www.stanford.edu/~sargent

[17] Judd, Kenneth L. (1998), *Numerical Methods in Economics*. Cambridge, Mass: MIT Press.

[18] Kydland, Finn E. and Edward C.Prescott (1982), "Time to Build and Aggregate Fluctuations". *Econometrica* 50:1345-70.

[19] Lahiri, Amartya and Carlos A. Végh (2000), "Should Interest Rates Be Raised to Fight Currency Depreciation". Working Paper, Department of Economics, University of California, Los Angeles.

[20] Lucas, Rober E.,Jr. (1976), "Econometric Policy Evaluation: A Critique", *Carnegie-Rochester Conference Series on Public Policy: The Phillips Curve and Labor Markets 1*, 19-46.

[21] Ljungqvist, Lars and Thomas J. Sargent (1999), Recursive Macroeconomic Theory. Unpublished Manuscript, Stockhold School of Economics and Hoover Institution, Stanford University.

[22] Marcet, A (1988), "Solving Nonlinear Models by Parameterizing Expectations". Working Paper, Graduate School of Industrial Administration, Carnegie Mellon University.

[23] _____(1993), "Simulation Analysis of Dynamic Stochasatic Models: Applications to Theory and Estimation", Working Paper, Department of Economics, Universitat Pompeu Fabra.

[24] McCallum, Bennett (1999a), "Theoretical Analysis Regarding a Zero Lower Bound on Nominal Interest Rates". Web page: www.gsia.cmu.edu/afs/andrew/gsia/bm05/theoreticalanalysis.pdf.

[25] _____ (1999b), "Recent Developments in the Analysis of Monetary Policy Rules", *Federal Reserve Bank of St. Louis Review* November/December.

[26] _____ (1999c), "Analysis of Monetary Transmission Mechanisms: Methodological Issues". Web page: ww.gsia.cmu.edu/afs/andrew/gsia/bm05.

[27] Mendoza, Enrique G. (1995), "The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations", *International Economic Review* 36, 101-137.

[28] _____ and Martín Uribe (2000), "The Syndrome of Exchange-Rate Based Stabilizations and the Uncertain Duration of a Currency Peg". Discussion Paper No.121, Institute for Empirical Macroeconomics, Federal Reserve Bank of Minneapolis.
_____ and Martín Uribe (2000), "Devaluation Risk and the Business Cycle Implications of Exchange Rate Management", forthcoming, *Carnegie-Rochester Conference Series on Public Policy*, 53.

[29] Michalewicz, Z. (1996), *Genetic Algorithms + Data Structures = Evolution Programs*. Thrid Edition. New York: Springer-Verlag.

[30] Mishkin, Frederic S. (2000), "Inflation Targeting in Emerging Market Countries". NBER Working Paper 7618.

[31] Ostry, J. and C. Reinhart (1992), "Private Saving and Terms of Trade Shocks", *IMF Staff Papers*, 39, 495-517.

[32] Rotemberg, Julio and Michael Woodford (1998), "An Optimization Based Econometric Framework for hte Evaluation of Moentary Policy: Expanded Version". NBER Technical Working Paper, No. 233.

[33] Saches, Jeffrey (1997). "The Wrong Medicine for Asia". The New York *Times*, November 3.

[34] Sargent, Thomas J. (1997), *Bounded Rationalilty in Macroeconomics*. Oxford: Oxford University Press.

[35] Schmitt-Grohé, Stephanie and Martín Uribe (2000), "Liquidity Traps with Global Taylor Rules". Unpublished manuscript. Department of Economics, University of Pennsylvania.

[36] Sims, Christopher (2000), "Solving Linear Rational Expectations Models", Mansucript, Department of Economics, Princeton University.

[37] Stiglitz, Joseph A. (2000), "What I Learned at the World Economic Crisis", *The New Republic*, April 17.

[38] Taylor, John B. (1993), "Discretion vs. Policy Rules in Practice". *Carnegie-Rochester Conference Series on Public Policy* 39, 195-214.

[39] Uribe, Martín (2000), "Real Exchange Rate Targeting and Macroeconomic Stability". Unpublished mansucript, Department of Economics, University of Pennsylvania. Web page: www.econ.penn.edu/~uribe.

[40] Végh, Carlos A.(1992),"Stopping High Inflation: An Analytical Overview". *IMF Staff Papers*, 39, 626-695.

[41] _____, "Monetary Policy, Interest Rate Rules and Inflation Targeting: Some Basic Equivalences". Working Paper, Department of Economics, University of California at Los Angeles.